



Low Volume Roads

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# introduction

For over 60 years we have successfully delivered numerous physical and social infrastructure solutions, and engineering projects to clients in over 100 countries in Africa, Asia, Europe, Latin America, Middle East, the Caribbean and the Pacific. Throughout this period, we have continuously been involved in the development of low-volume road (LVR) infrastructure.

We have been heavily involved in the research which has been undertaken in South East Asia and Africa over the past ten years. This work began in 2004 under a Department for International Development (DFID) funded research programme called the South East Asia Community Access Programme (SEACAP), which ran from 2004-2009 in Lao PDR, Cambodia, Sri Lanka and Vietnam.

In Lao PDR we oversaw the construction of trial sections of different pavement types such as bamboo reinforced concrete, concrete paving bricks, Otta seal, sand seal, gravel and hand-packed stone. The project provided invaluable information on the performance of these pavement types in the region and what is best to use in future.

When SEACAP ended, it led to a similar research programme commencing in Africa in 2008. This on-going research programme is also funded by DFID and is called the African Community Access Programme (AFCAP). As part of AFCAP, we are currently undertaking a project in two locations in Tanzania, similar to that completed in Lao PDR. In the areas of Bagomoyo on the east coast and Siha on the slopes of Mt. Kilimanjaro, we have designed and overseen the construction of a number of trial sections, constructed from paving blocks, concrete, Otta seal, penetration macadam, sand seal and gravel.

Monitoring the performance of these pavements will continue under the supervision of local engineers for the next 8 years, however, it has already provided valuable information on pavement options for use on LVR in Tanzania.

Also under AFCAP, we have trained the Ethiopian Roads Authority (ERA) in the use of surface dressings on their LVR and have provided support to a project which investigated the use of sand as a pavement construction material in Southern Africa.

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As AFCAP consultants, our main aim at this stage is to transfer our LVR knowledge to West Africa. From what we can ascertain, much of the focus thus far has been on work in Eastern and Southern Africa. We are hoping we can plant a seed in the minds of Engineers in Sierra Leone on the importance of the LVR network and commence a process aimed at developing capacity, instigating low-volume road research and developing design guidance and manuals for the benefit of future development in the country.



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# low volume roads

## Description

Low-volume roads (LVR) tend to be unsealed gravel and earth roads connecting rural communities with the strategic road network, in addition to vital public services such as schools, hospitals, farms and markets. They constitute a significant proportion of the African road network, which can be upwards of 80-90% of the overall network length in many countries.

## Technical Definition

An LVR is one which carries few vehicles on a daily basis and where the percentage of heavy vehicles is very low (5-10%). Typically, it carries <300 vehicles per day and less than 1.0 million equivalent standard axles (mesa) over its design life - although some say this upper boundary should be 0.5 mesa.

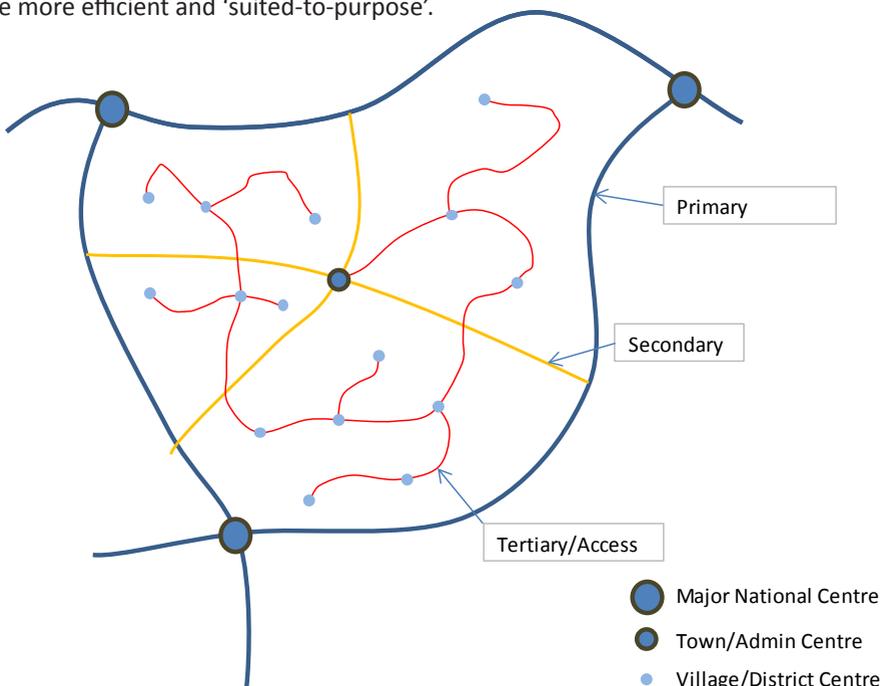
## Status Quo

At present, many countries continuously re-gravel their rural road networks, or upgrade earth roads to gravel standard. Gravel roads offer the cheapest alternative in terms of capital construction costs; however, in many cases the whole-life costs exceed that of a paved road. Additionally, this approach generally does not address environmental issues which prevent year-round access, particularly during the rainy season.



Paved roads are expensive and they can be difficult to justify on LVR which carry very little traffic. This cost is increased when inappropriate design standards, such as conventional pavement design manuals (e.g. Overseas Road Note 31), are used, as these result in expensive over-designs. To make LVR construction more cost-effective, appropriate design guidance must be used which tailors the design solution to the task in question.

New LVR Manuals accommodate much lower traffic categories. They also relax the specifications for base material and reduce pavement layer thicknesses so designs become more efficient and 'suited-to-purpose'.



# benefits from improving

## Social

It is difficult to economically justify upgrading LVR because most of the project benefits are social, rather than economic. Economic appraisal tools, such as HDM IV, quantify benefits in terms of vehicle operating costs and time savings, however, these benefits can be small for LVR.

Social benefits from improving the LVR network and providing year-round, reliable access include:

- Easier access to local markets, which is of particular benefit to farmers and traders
- Increased school attendance as children are no longer impeded by poor access in the wet season
- Better access to local clinics and hospitals – the World Bank has observed a link between poor road transport and increased childbirth mortality rates
- Improved private and public transport through lower road-user costs
- Through each of the above, increased quality of life and provision of enabling tools for reduction of extreme poverty

Many of these benefits were recorded by Roughton on a LVR research project in Tanzania.



# rural road infrastructure

A Sociologist interviewed many local residents and each gave their opinions on how the new road has impacted their lives. These responses are displayed toward the end of this document.

## **Environmental**

Re-gravelling is an unsustainable process which has resulted in the depletion of gravel resources across the African continent. Better use must be made of this valuable, finite resource. We cannot continue to exploit it indefinitely into the future through continuous re-gravelling of our LVR.

Gravel also poses a dust pollution problem which impacts upon health, particularly in villages, and in the quality of crop production in road-side areas.

## **Whole-Life Costs**

The whole-life costs of a paved road can be significantly less than that of a gravel road. This is because routine maintenance costs are greatly reduced. Whilst a gravel road can require re-gravelling every 3-5 years, a sealed road will typically only require pothole patching and crack sealing until such time as a re-seal is required – which could be after ~10 years.

Alternative surfaces such as concrete or paving bricks can incur cheaper maintenance regimes, albeit slightly higher capital construction costs.



Lawate to Kibongoto Road

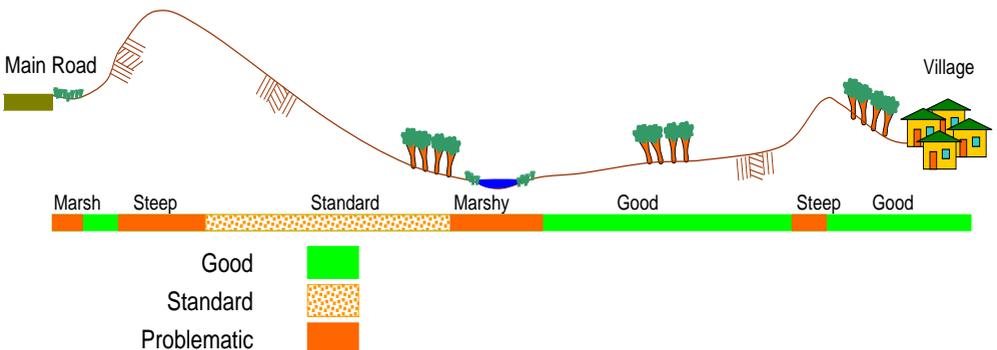
# environmentally optimised

Environmentally Optimised Design (EOD) is a philosophy focused on creating the most efficient design-set for a given road, which can range from upgrading the whole road to doing spot improvements.

EOD can be thought of through a combination of the following two criteria:

- You only need to fix the sections which prevent year-round access e.g. areas which are impassable in the wet season
- You should use locally sourced materials and tailor your designs to the engineering problems at each location. For example, if there is lateritic gravel in the area, select a pavement solution which can be constructed from it. Conversely, don't select a design which requires crushed stone if there is none available locally

The idea is to make the provision of year-round access as economical as possible. In many cases 90% of the road is accessible all-year round. However, if even one section becomes impassable during periods of inclement weather, this can cut access to communities located after this point.



# design

Therefore, it is vital that this section is given a robust pavement solution which solves the access problems experienced in that area. However, there may not be any need to provide expensive pavements to the remainder of the road. In this way, you spend money where it is necessary and you save money in areas where upgrades are not required.

This is a shift away from the two alternatives:

- Re-gravelling because it is cheap – however, it is unlikely to solve the access problem, which may return during the next rainy season, or
- Paving the whole road. Whilst this may fix the problem, it will be expensive and may not be necessary



*Lawate Market, Tanzania*





Projects in Tanzania, in partnership with AFCAP and DFID, illustrating socio-economic benefits of low volume road improvements



# Increasing Access to Healthcare

How AFCAP is helping to provide safe, reliable and sustainable access to healthcare in Tanzania

Over 95% of the Tanzanian population are at risk of Malaria. With approximately one million deaths and more than 400 million cases a year in sub-Saharan Africa, it is the leading cause of morbidity and mortality. In the Siha district of Northern Tanzania access to health facilities can be the difference between life and death.

The Lawate to Kibongoto road, on the foothills of Mount Kilimanjaro, is characterised by steep hills and red volcanic soils which immediately becomes impassable when wet. This makes accessing health facilities problematic. But, Roughton is currently providing consultancy services to the upgrading of the road to all weather standard, under the African Community Access Programme (AFCAP), so that health facilities can be accessed all year round.

Nursing officer Aingaya Mlay has lived on the road in Lawate for eight years. "The road was not good and it was slippery especially during the rainy season," she recalls, "Someone may be suffering from Malaria and the road is bad and it is far because there is no transportation and they decide to sit at home."



*"The road will be very helpful for us because when people are getting sick they can get to the hospital in a short time"*  
Nursing Officer, Aingaya Mlay

"Now the patients will not delay," says the 50-year-old. "Most people will access the hospital because of the road."

Elamani Maimu, a 52-year-old farmer from Orumwi, agrees that lack of transport limits access to healthcare. She says: "Sometimes people are carried by chekecheke." "This is a kind of sieve used to clean maize which villagers use as a kind of improvised stretcher," she explains.

"When it is dry you might get transport but when it is raining even if you call someone they will not come to pick you up," she recalls. But, "Now I think it will be easier because even when it is raining you will call a boda-boda owner and they will come and take patient to the hospital," she adds. "My life will change for the better completely."

"A big problem was the delivery, at night pregnant women who want to deliver would wake people in the village to escort them to the hospital," explains Aingaya. "But now they can call from their home or a neighbours phone and the motorcycle will come and take them to hospital." "I was not sleeping. They used to wake me up to escort them but now I am sleeping. They go straight to the hospital without disturbing me," she says.

They go straight to the hospital without disturbing me," she says.

Health workers used to visit the villages once a month to provide vaccination services. But, now mothers are able to take their babies to the hospital because there is transport. "The road will be very helpful for us because when people are getting sick they can get to the hospital in a short time," she says.

The construction of the road has already improved Aingaya's travel time to her workplace at Hai District Hospital. "Before, it took four hours so I had to wake up very early in the morning. Now it takes one hour to half an hour," she says. "I used to wake up at 4am to get to work but now I can get up at 5.30am. I sleep more without thinking of waking up early."



Kirisha Primary School students holding the chekecheke, which is used as an improvised stretcher

# Getting Farmers to Market



How AFCAP is helping farmers get to market by improving access in Tanzania

In Siha district in Northern Tanzania, on the foothills of Mount Kilimanjaro, the Lawate to Kibongoto road serves a highly productive agricultural area where one of the biggest sources of income is generated from selling milk and farm produce.

Farmers work on both sides of the road for its entire 13.5km length and need a route that is passable in all weathers so that they can earn a living all year round. The road, which is characterised by steep gradients and red volcanic soils, is passable in dry weather but immediately becomes impassable when wet. Roughton is currently providing consultancy services to the upgrading of the road to all weather standard, under the African Community Access Programme (AFCAP), so that farmers can access the road all year round.

"The road is important for the community," says Siha District Executive Director, Rashidi Kitambulio. "It will increase their income and the life standard for them because they can access their business, send produce to the market and it will be passable throughout the year."

"Economically it is going to improve very much," agrees Kashashi ward councillor Susanna Kihunrwa. "People will be very happy. It is going to make their lives easy."

"Before it was too slippery and it was difficult for people who were going to sell their commodities in the market," says Susannah who has lived on the road for 40 years. "Especially women, when they want to sell their commodities they have to carry it on their head and pass through slippery roads, so they find it difficult."

Dina, a 49-year-old farmer and livestock keeper who sells milk and farm produce at market describes the road before construction as "very very bad". "It was terrible," she says.

Lack of transport on the road limits the amount of produce that can be taken to market. Dina, who uses the road twice a day to travel to her farm and the local markets, explains: "When you are carrying a load with your head you will not carry enough produce

for you to sell at the market you will only carry the amount you can carry on your head." On her head she is able to carry a quarter sack of maize, 25kg, or up to 20 litres of milk. But, sometimes the pressure from carrying heavy produce like this causes the women to go bald.

When the road is complete vehicles will be able to pass in all weather. "We will not have to use our heads," she says. Every Monday and Thursday there is a market at the start of the road in Lawate. Dina says: "When it was muddy I used four hours to get to the market on foot. Now, I can use two to two and a half hours." But, she believes after the road is complete "transportation will be easier" and the journey will be quicker.

Also, the quality of the road before construction deterred visitors from coming to the area. Dina says: "There are many people outside the village who did not want to come to the village because the road was bad." But she believes the new road will help. "What we produce here they don't have so they will come to buy things like banana, plantain, milk and vegetables and they will leave money in the village so it will bring some development in the village," she says.

"Honestly, there will be very very big changes in our lives," she says. "We will produce more milk because we know there will be transport and the market will expand."

Dina will use her extra profit to send her five children to school and also to improve her house.



Milk is a major source of income for villagers in Siha



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# CHANGING LIVES

## Helping local businesses



**Imani Ali tells Roughton how the new road has changed his life for the better**

**B**usiness is booming for 33-year-old bike shop owner Imani Ali. His life has been transformed. It is hard to imagine that this time last year he was just a pineapple farmer earning money by selling his produce at market. But, now he is making a living from various businesses and hopes to open more in the future. How was this achieved? The answer is simple: access.

Roughton International has provided design and consultancy services for the upgrading of the Bago to Talawanda road in Bagamoyo, Tanzania, to all weather standard under the African Community Access Programme (AFCAP). The road, which was previously impassable in the rainy season has been redesigned and constructed using the Environmentally Optimised Design Approach to provide reliable access for rural communities in all weather. This development has caused an increase in transportation to the area which businessman Imani intends to profit from.

A year ago, Imani, originally a farmer from Msinune, invested money from his pineapple farm to open a bike shop in Bago, at the start of the new road. Here he sells spare parts for bicycles and motorcycles as well as renting bicycles to the local community.

Imani, was hard at work when we met with him at his busy bike shop. Rows of bikes are lined up outside ready to be hired. Each decorated with different football stickers so you can tell them apart. Inside you can see various bicycle parts, food and drink for purchase. He says that he opened the shop because he saw the road was being improved and wanted to make money from it. "Before if it was raining people didn't go anywhere. If you had a bicycle you would just leave it and go on foot. There was no type

of transport," he recalls. "But, now the road is good people can use bicycles every day."

"All the time people are coming here to get a bicycle to go to Talawanda or Chalinze," he says. Within 20 minutes Imani has had four customers. Before the construction of the road this would not have happened. But, now more people are passing. "If they need to buy a pump, tyre or water they stop and buy," he says.

**T**he road has had a positive affect on Imani's income. "If the road was bad I would have made less money," he says. "But, now the road is good more people pass and it is good for business."

Imani lives approximately 5km away in the traditional village of Msinune, home to over 2000 villagers. Many of the residents here are farmers and rely on this road to get to the market in Kiwangwa where they sell their produce. But, before the construction it wasn't even called a road. It was referred to as a passing.

Imani, who has lived near the road all of his life, has no alternative routes to get home. He says: "Now it is good because the road is safer. I can get home very quickly compared to before."

"Before if it was raining I was using two to three hours. Sometimes you slip and slide in the rain," he recalls. "This time I can use up to half an hour because the road is good."

**H**e says the road has had a positive affect on his life. "I can make more money and use the money to open more businesses like this one."

"Now the road is good people can use bicycles every day"  
Imani Ali, 33,  
Msinune





## HELPING BUSINESSES IN TANZANIA

### Vick Makundi tells Roughton how the new road will improve her business

Northern Tanzania, on the foothills of Mount Kilimanjaro, amidst the mayhem of Lawate market, a row of shops sit on either side of the Lawate to Kibongoto road. It is here that Roughton is currently providing consultancy services for the upgrading of the road.

Vick Makundi, a 30-year-old tailor, is hard at work in her fashion shop with her small team of workers. An array of colours and fabrics hang neatly on the wall ready to be transformed into customised clothing. There is no electricity. Workers use coal irons and manual sewing machines. The process is slow and demanding but no one is complaining.

Inside Vick Fashion you can hear the friendly chatter of workroom gossip and scissors slashing fabric. But, outside, labourers are working hard to upgrade the problematic rural road to all weather standard to provide reliable access for the community all year round. Vick says: "We are grateful for this support because there will be no transport problems anymore."

Characterised by steep gradients and red volcanic soils, which are firm but slippery when wet, the 13.5km road immediately becomes impassable when wet. "The road was very very bad, there were no cars going through it and if you wanted to go up you have to go on foot because of how slippery it was," she recalls.

The unreliable condition of the road means that Vick, who normally accesses the road by car, is "sometimes forced to walk

on foot" which makes her late for work. "Sometimes customers come to look for me and they miss me. If I was to make 2 dresses in a day I only end up making one because of the time lost," she explains.

Vick's biggest problem is transport. Sometimes, "we have to wait for market days to get transport," she says, which limits the number of customers she receives. Roughton International has redesigned the road under the African Community Access Programme (AFCAP), using an Environmentally Optimised Design Approach, to facilitate safe and sustainable rural access on a budget. Vick is hopeful that the new road will bring improvements. "There will be no problem of transportation anymore and people will be getting wherever they want and there will be more customers," she says.

"My life will be very good and very successful. I will get many customers, there will be a lot of business going on because so many people will be coming," she adds.

"My income will increase because customers will increase," she says. "The money that I get I will build a house and send my children to school and expand my business."

Vick, who has lived in Lawate for five years, has already noticed the difference the road is making. "Now there are no problems because they have put gravel unlike before when it was slippery," she says. "I feel very good and more than that I am very happy."



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# ENHANCING TRANSPORT IN TANZANIA

How AFCAP is helping transport operators by providing safe and reliable access

**E**astern Tanzania, rain falls heavily on the Bago to Talawanda road. Motorbike taxis, known locally as boda-boda, continue to speed past. But, this hasn't always been possible. Just over a year ago, the poor condition of the road under the stress of rain would have made it impossible for vehicles to pass. But now the road has been redesigned and constructed under the African Community Access Programme (AFCAP) to provide reliable access for rural communities in all weather.



Boda-boda operator Mohina Saidi (picture left) was taking a break in a restaurant at the start of the road in Bago when we met with him. The development of the road has increased the number of transport operators in the area. "Business is better now even though there is competition because travel time is shorter," he says. "The road is better and it gets rid of a lot of my problems."

"It was very bad before, very hard and difficult to pass. Sometimes we couldn't pass especially in the rain," he describes. "There was always accidents and people would hurt themselves."

The 28-year-old was involved in three accidents before the new road was constructed. "The first one I was taking a passenger to Talawanda, on the way it started raining, but I didn't have the information that it was going to rain," he recalls. "I fell off and hurt myself but my passenger was fine."

**A**fter the accident, Mohina had to ride his motorcycle to the hospital in Msata. He gestures to a scar on his leg and says: "It was very painful because heat from the bike made my injury worse."

"I haven't had an accident since the new road but my friends have," he says. "The problem is not the road it is the cars." "The cars use high speeds and because the road is narrow they don't want to give motorcycles space to pass," he explains.

Habibu Milaji (picture right) lost two of his front teeth in a boda-boda accident shortly after the road was complete. "The driver

was going very quickly, about 60 km/h. Ahead you can see a sharp corner," he recalls. "The motorcycle hit some small stones and swerved."

The 54-year-old livestock keeper was knocked out on impact and woke up two hours later with some memory loss. "People came to the accident and were like 'wow he's dead'," he says. When he came around he was taken to the hospital where he remained for two weeks. "Even now I don't have teeth," he smiles. But, despite his injury Habibu does not blame the road for the accident. "Maybe it is because the drivers are going quickly," he says. "There is not a lot of accidents now."

**R**oad traffic injury is a killer, which kills more people than HIV, Malaria and Tuberculosis worldwide. Which is why AFCAP is working with Amend NGO to provide road safety research and education. "Our concern is rural communities with little understanding of fast roads and conflict between fast cars and pedestrians," says Tom Bishop from Amend NGO.

Mohina is very safety conscious. "I wear a helmet with a visor to protect myself from wind, insects and dust. Also, I am afraid of accidents and traffic police," he explains. A motorcycle passes carrying four passengers. He looks at them disappointed and says: "The most people I take on my bike is two and myself" Mohina taught himself to ride but would like to learn about road safety. "If someone could help me get training or go to college I would be very happy," he says.

But, before construction, accidents were not the only problem. The fear of being ambushed by bandits at night caused the price for boda-boda to double. "I am afraid of the passenger stealing from me. You get to a destination and passenger takes the bike and maybe even kills you" he says as he gestures slashing his throat. "I don't carry a knife myself but other boda-boda drivers do." "Nobody has been attacked since the new road. If somebody had I would know," he says.



# Better access to healthcare

How AFCAP is helping pregnant women in Tanzania access health facilities



38 year old farmer, Mwajuma Haji Athumani, reveals how the condition of the new road could have saved her baby's life

Every year around 50 million women give birth without skilled care. The vast majority of these women live in developing countries like Tanzania. In rural Bagamoyo a major problem is access. Many of the roads are difficult to travel on and transport during rain can be impossible. The Bago to Talawanda road was in such poor condition that the local community did not call it a road. It was called a passing. Roughton has provided design and consultancy services, under the African Community Access Programme (AFCAP), to provide reliable access for rural communities in all weather, allowing pregnant women to access the health facilities that they need at any time.

"Before construction we were just using natural medicines for caring," says Talawanda West Village Chairman Saidi Dibwe. "But now many sick people are able to be transported."

Three years ago, before the road was constructed, Mwajuma Haji Athumani, 38, went into labour at home in her village of Kiembe. She stares at the ground and says: "I am too ashamed to talk about it." The mother-of-five was too distraught to tell the story in her own words but she wanted her story to be told.

It was raining heavily the night she went into labour. The road had become more of a river than an access route. No vehicles could pass; the only access was by foot. It was very muddy and slippery. The road towards Kiwangwa hospital was completely impassable in the rain so Mwajuma faced a difficult 10km walk to the nearest medical dispensary in Talawanda. It was a painful two-hour walk in terrible conditions and when she arrived at the dispensary the doctor was not there.

Still desperate for someone to deliver her baby she faced another four-hour walk to the next hospital in Chalinze, 20km away. But, upon arrival she faced the news that they couldn't help her so she was sent to the Tomby Kibaha Hospital. The baby did not survive the journey. Mwajuma gave birth at the side of a road, without any medical assistance, to a baby that was already dead.

She believes that if the road was better her baby would still be alive. "The doctor suggested that if the road was better children wouldn't die," she says. "Thank you for constructing that road. Now we can manage to get to the hospital at any time. Thank you. Thank you. Thank you."

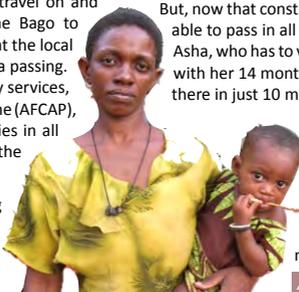
Mwajuma, who normally travels by bicycle, recalls: "Before the road construction there was many many problems. The road was very bad. We used only bicycle to travel from one place." But, pregnant women are unable to ride because the vibrations created by the bad condition of the road can be dangerous.

Asha Faraha, 35-year-old mother, from neighbouring village Ludiga, used a bicycle for the first three months of her pregnancy. "But, after that I had to walk because it created a pain in my back," she recalls. "Sometimes if I go on bicycle I urinate on the bicycle. So it forced me to walk," she says.

But, now that construction has finished, cars and motorcycles are able to pass in all weather. Thanks to the increase in transport, Asha, who has to visit the dispensary in Talawanda every month with her 14 month old baby, Subira Ibrahim, is now able to get there in just 10 minutes.

"Now you can travel easily from one place to another," agrees Mwajuma. There is even a public bus that comes once a week. This allows for access to health facilities at any time. "The situation is good because you are able to travel at any time, even at night," she says. "Now my health is good."

Asha Faraha, 35, with baby Subira



**AFCAP**



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# who are we?

An independent organisation founded in 1952, we have built a reputation for efficiency, value for money, innovation and timely project delivery.

Excellent client relationships and long term fostered business partnerships worldwide have made Roughton a unique brand.

In the UK our public sector client list includes numerous NHS trusts, local authorities and ministries. Banks and major construction contractors are found amongst our growing private sector list.

Further afield, Roughton has successfully delivered projects funded by all the major IFIs. Projects include an urban development project in Lagos in Nigeria, asset management projects in Uganda, development of the Jamaica Inner City Basic Services, Institutional Strengthening projects for the Frontier Highways Authority of Pakistan, the China to Europe highway in the Republic of Kazakhstan, various infrastructure projects in India, Sri Lanka and over 100 other countries.

We are providing Transaction Advisory services on PPP and PFI projects for several governments and private developers in a number of countries including Georgia, Nigeria and India. We understand the need for private sector investments and how to make them effective.

From undertaking the smallest bridge inspection to providing expertise on the largest and most complex infrastructure projects, we will provide the same level of professionalism and client care ■

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# other services

- Air quality
- Asset management
- BIM
- Bridge engineering
- Building services
- Building surveying
- CDM coordinator
- Civil engineering
- Construction supervision
- Contract administration
- Due diligence
- Drainage design
- Economic feasibility
- Energy efficiency
- Environmental impact
- Expert witness
- Facilities management
- Feasibility studies
- Flood risk assessments
- Geotechnical investigations
- Highway engineering
- Hydrological studies
- Infrastructure design
- Intermodal appraisal
- Landscape architecture
- Masterplanning
- Pavement engineering
- Planning
- PPP & PFI
- Programme management
- Project management
- Public health engineering
- Quantity surveying
- Rail engineering
- Risk management
- Secondment of professional staff
- Structural engineering
- Transportation planning
- Water
- Wastewater

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